SOIL TEMPERATURE MEASURINGS ON THE SUDDS OF LAKE VELENCEI/HUNGARY

by

M. BALOGH* – S. ANDRIKOVICS – B. CZEGLÉDY** – P. KECSKEMÉTHY**
A. PATKÓ** – L. VÁRI**

Department of Systematic Zoology and Ecology of the Eötvös Loránd University, Budapest * National Institute, for Education, Budapest
** Ho Si Minh Teachers' College, Branch of Budapest

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The Mezőföld region – larger environs of Lake Velencei – is phytogeographically as well as climatologically a part of the Alföld (Great Hungarian Plain), a region of Hungary being after the Duna–Tisza köze (Region between the rivers Danube and Tisza) the area richest in sunshine. The yearly precipitation amount is generally below 600 mm.

According to the meteorological literature the climate of the Mezőföld is continental. B o r h i d i stated in 1961 on basis of the climate-diagrams of W a l t e r related to this territory that in the climate of the Mezőföld the submediterranean effect is determinating, prevailing. (Within more than 60% of the investigated years a submediterranean precipitation distribution was found.)

Thus in the vegetation of Lake Velencei and its direct vicinity we could expect the occurrence of mainly Pontian, Pontian-Mediterranean, Pontian-Pannonian furthermore continental flore-elements. All these we may actually find in the woods, in the sandy meadows of the Mezőföld furthermore in the woods and rocky grasses of the Velencei Mountains but in Lake Velencei and on her shores rarely. The proportion of the Eurasian, circumpolar and cosmopolitan flora-elements is very big in the flora of the lake and the saline meadows of her environs. This is quite understandable since these are not climatezonal but edaphic plant associations.

From 1968 in turn a series of interesting floristic discoveries commenced in the sudd region of the lake (B a l o g h 1968, K i s s – B o r h i d i – V a j d a 1973, B a l o g h 1978, B a k a l á r n é – B a l o g h 1979). But this time also not masses of Mediterranean species were found but Atlantic, montane, boreal and circumpolar of Nordic range flora-elements were found under the here prevailing climatic and edaphic circumstances (saline lake!) being alike very unusual.

Such an augmentation of the flora-element spectrum made necessary the microclimatic investigation of the sudd-world. The heat conditions of the soils of the sudds were in first line which aroused our attention. It is well-known from the literature that the microclimate of the reeds and the woods is more humid, more cool, more egalized than that of their environment, namely that of the open water and meadows, which is needless to discover again. But in our reeds and woods not the Atlantic, boreal and montane elements are charactersitic; thus the exuberance of such elements of the sudd-reeds and marshy sudd-woods we credited to the effect of the special microclimate of the sudd-soil. We were reassured in this supposition by a short data series of the previous ecological investigations: on 18th August, 1968 between 12–13 PM in two sudd trans, the water temperature was lower by 4–5 C (= centigrade) in 60 cm depth than that of the open water (Balogh 1970, Borhidi – Balogh 1970). The authors supposed that the sudds cool by their shading effect and by that they stabilize strongly the position of the water bodies below the sudds and decrease essentially the speed of the biochemical processes taking place in them.

Since then we have known that the essential part of the lake is covered by sudds, thus we consider that from the view of the water quality economy (and likely also for the water-balance calculations) it is very important to become acquainted with the microclimate of the sudds, in first line the temperature course of the sudd-soils; – the effect of the sudds onto the water climate.

The principal aim of our work was to become acquainted with the temperature course of the different layers of the sud-soils on some biotopes (as furze thickets, sudd-reeds, *Sphagnum*-cushion,) as well as the temperature course in the sudd-tarns and in possession of this knowledge to be able to establish the microclimatic attributes characteristic to the sudd-soil.

Location, date and method of the investigations

We carried out our investigations in the Pyrolan woods beside the Kuti-groove (Fig. 1) (soil and thick litter-layer) and in the turf fernery reeds beyond the woods (typical turf fernery reeds, *Sphagnum*-cushions, sudd-tarn) on the following stations:

1. on the soil of the Pyrolan furze thicket. We measured the temperature of the soil on the surface, in 5, 10, 20, 30 and 40 cm depth.

2. in the Pyrolan woods in the thick heaped litter at the stock of the furzes. We measured the litter-layer temperature on the surface, in 5, 10 and 20 cm depth.

3. in the turf fernery reeds (at the edge of the woods) in *Sphagnum recurvum* cushion and in the *Sphagnum girgensohnii* cushion. We measured temperature of the soil in the *S. recurvum* cushion on the surface and in 5, 10, 20, 30 and 40 cm depth, in the *S. girgensohnii* only on the surface. (We wanted to save unconditionally this boreal *Sphagnum* species which leaves the taiga forest zone resp. the coniferous mixed forest zone only in the direction of the Atlantic, resp. the subarctic territories and it is

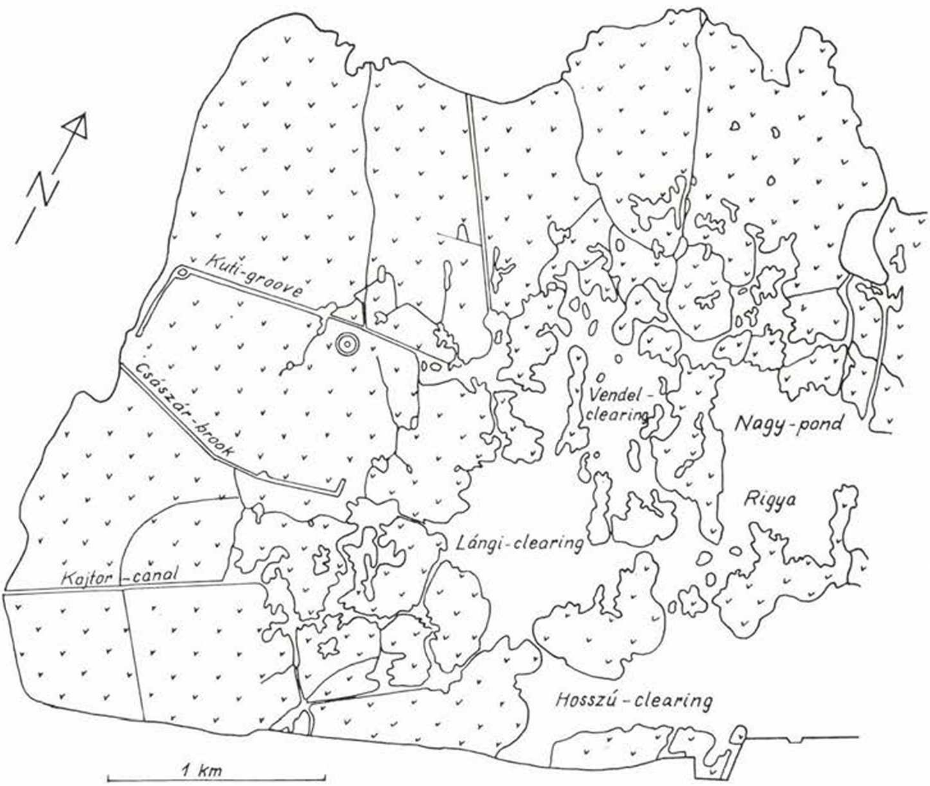

Fig. 1. Sketchy layout of the investigational spots. (Western half of the Lake Velencei) ⊙ = locality of measuring stations on the sudds

islandlikely spread on the Central-European montane region, mainly in the spruce belt – see the map in Bakalárné – Balogh 1979).

4. in typical brush-dense turf fernery reeds. We measured the soil temperature on the surface and in 5, 10 and 20 cm depth.

5. in the sudd-tarn in the vicinita of the *Sphagnum*-cushions. We measured the water temperature on the surface and 50 cm deep.

Our measurements were carried out from 22nd August, 13,00 PM to 24th August, 1978 08,00 AM with an hourly frequency. We used (on the surface) mercury station thermometers and bent-neck mercury soil thermometers.

On the surface of the investigated soils there is a thinner or thicker, generally dry litter-layer. Both the surfaces of the litter-layer as well as of the *Sphagnum*-cushion are very loose, uncertain. Therefore when measuring on the surface – in order to avoid the experimental mistakes – we sunk the marcury capsules of the thermometer (cca 2 cm) into this loose, hardly limitagle surface (similarly as it is usual when measuring the water surface).

Results and their evaluation

The results of our measuring series are represented graphically. On the graphs our results got in the 10 and 30 cm depths are not indicated since the temperature courses of the 10 and 20, resp. the 30 and 40 cm depths are very similar, their common presentation would have made the graphs baffling. Therefore we illustrated the measured data in10 and 30 cm depth only on the funnel-diagrams. We present our results in the sequence of the measuring stations.

1. In the Pyrolan furze thicket marshy woods the temperature of the soil oscillated 30 and 40 cm deep between 15.9 – 16.2 C (0.3 C), this is thus a zone of very steady temperature. The oscillation experienced here is practically not more than the possible measuring error. The end values on 20 cm are 16.4 and 16.8 C, on 10 cm however 16.1 and 16.8 C (the oscillation being 0.4, resp. 0.7 C). The temperature oscillation measured at these levels is not much more than the possible measuring error either. The temperature of the 10 – 20 cm zone is generally by 0.5 C warmer than of the 30 – 40 cm zone. In the 5 cm layer (although strongly absorbed) the effect of the air temperature is sensible. This layer has also a very small temperature oscillation; between 15.8 and 17.6 C (the absolaure oscillation being 1.8 C), the temperature minimum of this layer is below that of the 30 – 40 cm layer, while its maximum is above the 10 – 20 cm layer. The temperature of the surface is between 15.1 – 18.4 C (absolute oscillation 3.3 C), this is also very low. (Fig. 2)

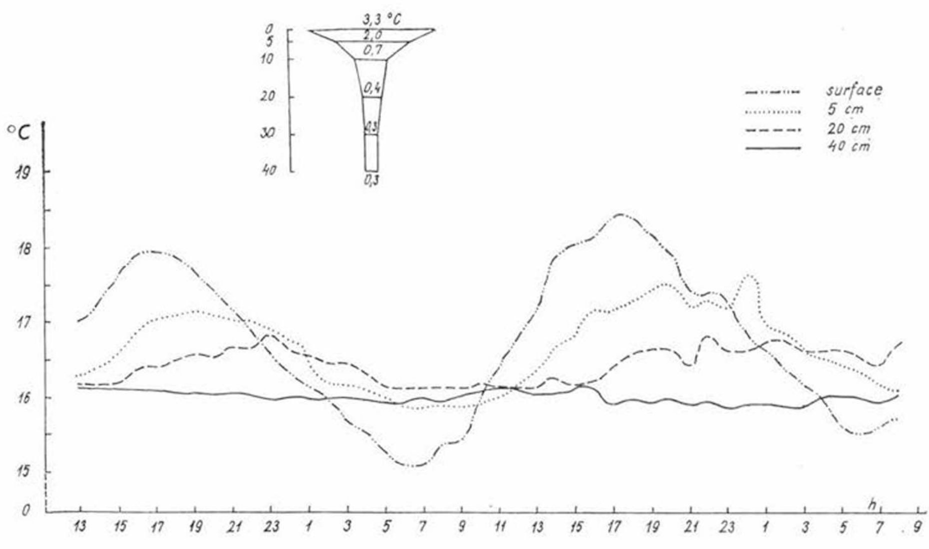

Fig. 2. Temperature course of the turf soil of a furze thicket willows woods (on the 22 – 24th August, 1978)

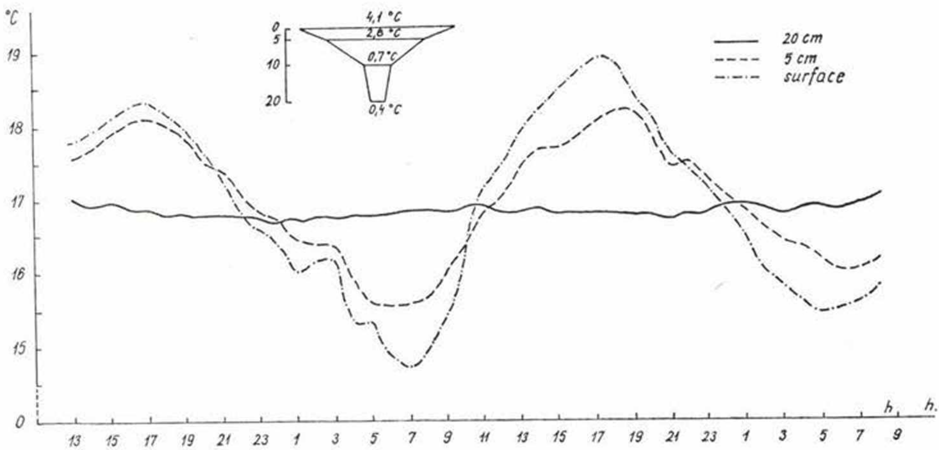

Fig. 3. Temperature course of the litter layers of a furze thicket (on the 22–24th August, 1978)

2. In the thick, dry litter layer of the Pyrolan woods the temperature oscillation was in 20 cm 0.4 C (16.6 – 17.0 C), in 10 cm 0.6 C (16.6 – 17.2 C), in 5 cm 2.6 C (15.6 – 18.2 C), on the surface however 4.1 C (14.7 – 18.8 C). The 10 – 20 cm thick litter layer is a couple of tenth C warmer than the water saturated soil (presumably as the consequence of the much richer soil-life), the average temperature is in 5 cm depth and on the surface also higher with a couple of tenth C than on the watery turf soil, but the daily temperature oscillation is also more extreme. (The specific heat of the dry litter is certainly less than of the water saturated turf, that is why it reacts to the identical heat effect with greater temperature oscillation.) (Fig. 3)

3. Under the *Sphagnum recurvum*-cushion the temperature oscillation was in 40 cm depth 0.3 C (15.3 – 15.6 C) during the investigation, 30 cm deep 0.5 C (15.3 – 15.8 C), 20 cm deep 0.4 C (15.6 – 16.0 C), 10 cm deep 0.3 C (15.5 – 15.8 C), 5 cm deep 1.4 C (14.9 – 16.3 C), on the surface however 8.2 C (12.4 – 20.6 C). The surficial temperature oscillation of the *Sphagnum girgensohnii*-cushion was 8.8 C (11.9 – 20.7 C). In the 10 – 40 cm depths the temperature course of the soil is similar to that of the soil of the willow woods, the absolute oscillation of the singular levels does not exceed or exceeds almost none the error possibility in reading, but the temperature of the singular layers is more than 0,5 C colder. In the 5 cm layer the effect of the temperature course of the air is here sensible too, but it is still less (1.4 C) than that of the willow woods soil (1.8 C) and of the litter (2.6 C). On the surface however is the temperature oscillation significant. It is interesting to note that the temperature course of the surface of the *Sphagnum girgensohnii*-cushion is more extreme than that of the *Sphagnum recurvum;* ceertainly it evaporates strongerly, since it is colder almost all the day than the *S. recurvum* (it happens that by more than 1 C),

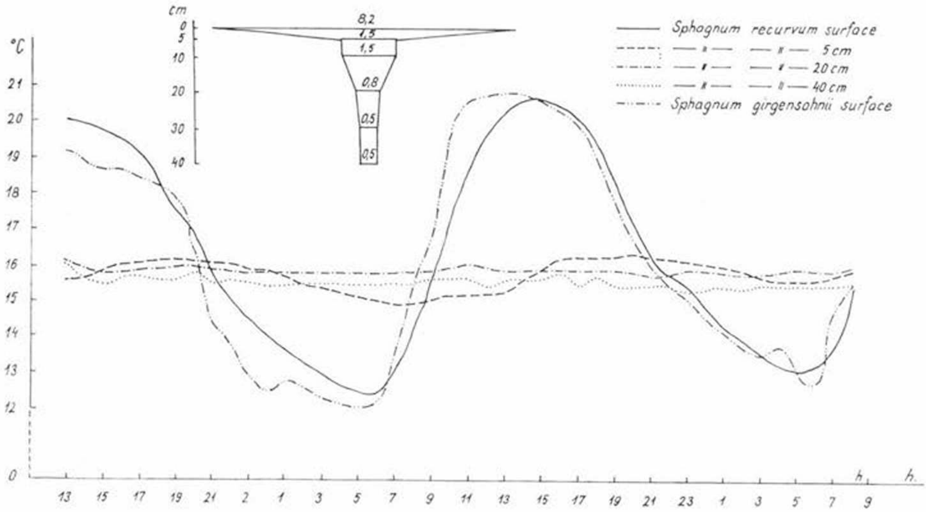

Fig. 4. Temperature course of the soil of *Sphagnum recurvum* and *S. girgensohnii* grasses (on the 22–24th August, 1978)

and only in the morning-noon hours when the *S. recurvum* was not accordingly shaded, it exceeded a bit the temperature of that. Fig 4)

4. The temperature oscillation of the soil of the turf fernery reeds was in 20 cm depth 0.4 C (15.7–16.1 C), in 10 cm 0.6 C (15.8–16.4 C), in 5 cm 1.0 C (this is the lowest in this level! – 15.4–16.4 C), on the surface however 3.4 C (14.3–17.7 C).

The temperature course of the corresponding layers in the soil of the reeds is similar to the woods soil and to the soil beneath the *Sphagnum*-cushion; this soil is much colder then the woods soil – and just warmer than the soil beneath the *Sphagnum*-cushion. Only the surface differs from this general picture, – here is only the temperature course of the soil of the woods and reeds similarly egalized, that of the Sphagna is more extreme. (Fig 5) Thus the soil of the reeds is almost that cold, than that of the *Sphagnum*-cushion and such egalized than of the woods. This might be very surprising but considering the possible reasons more profoundly, we think that the very dense reeds with its closed turf fernery level (and beneath as well as above this level with many marshy plants) shades the soil better than the sparse foliage of the willows. On the contrary the reeds is a more lower plant association and its really dense turf fernery layer is yet much more lower! Thus the active surface is very low and the transpiration is very intensive in the proximity of the soil. The willows, although more sparse, much higher, richer levelled, thus the active surface has a great depth, it is not defined. The air space of the willow woods is morehumid (in daylight when irradiated!), than than of the reeds thus the evaporation of the soil level is much less.

Comparing our measuring results to the temperature course of the soil of the marsh meadows, we may extablish that the investigated four

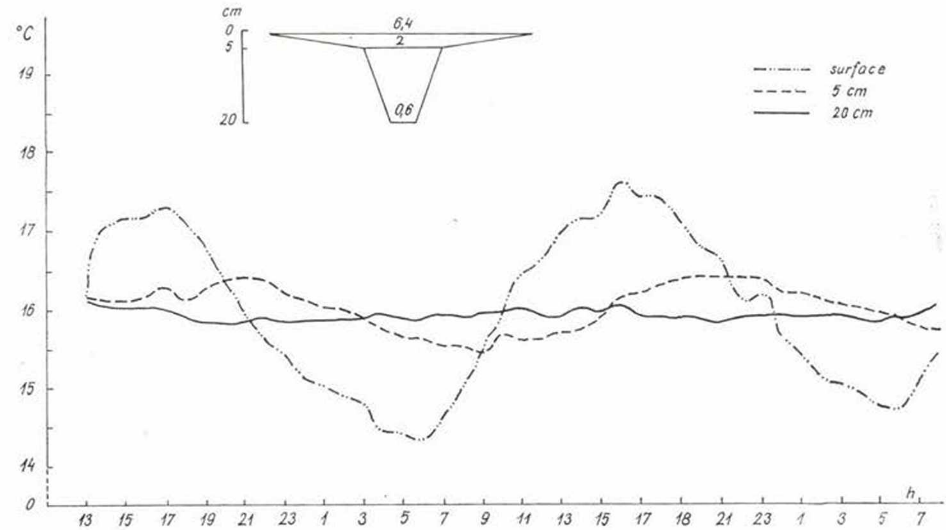

Fig. 5. Temperature course of the soil of a turf fernery reeds (on the 22–24th August, 1978)

soils have a similar temperature course in the corresponding layers (except for the surface of the *Sphagnum*-cushion!) and it differs definitely from that of the marsh meadows soils.

The daily temperature oscillation of the sudd doils is on the surface – as seen – 3.3–3.4 C, that of the dry litter 4.1 C and on the surface of the Sphagna still only 8.2–8.8 C. Comparing these with the data of M. Kovács from 1962, we may establish that the daily temperature oscillation on the surface of the marsh meadows is much higher (namely 11.8, 11.8, 16.8, 17.8 and 20.7 C). The temperature oscillation of the two associations most spread in the lake, namely of the sudd reeds and of the furze thicket on the surface corresponds approximately to the 15 cm depth of the soil of the marsh meadows (2.0, 2.2, 3.2, 3.2 C). The temperature course (1.0, 1.4, 1.8 and 2.6 C) of the four investigated sudd soils corresponds in 5 cm depth to the 20 cm layer of the marsh meadows soils, where the radiation and irradiation make their effect felt almost none; in 10 cm however the temperature oscillation of the sudd soils (0.3, 0.6, 0.6 and 0.7 C) is verging on the possible error in reading – this corresponds with the temperature course to be experienced in 30–50 cm depths of the soil on marsh meadows. Thus the temperature course of the soil of the sudds is more egalized than that of the marsh meadows, the effect of the radiation and irradiation is much less in the depth and also in the surface (even on the surface of the *Sphagnum* either!) it proves to be effectual in much lesser extension.

It is at least so illuminating to compare our results to the data of a *Sphagnum* marsh (J e f i m o v a in: S e n n y i k o v 1953, Fig 147). The temperature oscillation of the surface is here 27 C, 10 cm deep 16 C, 25 cm deep however only several tenth of a centrigrade, this layer is practically quiescent. The oscillation of the surface is thus much bigger also in the marsh meadows, the formation of the evenly temperatured layer falls however between the evenly temperatured layers of the sudd and marsh meadows (10, resp. 30–50 cm).

Comparing it with the mesoclimate of Lake Velencei, we may establish that here is not only the microclimatic effect in question! This sudd world of several square kilometers extension has very interesting mesoclimatic features, very differing from the macroclimate, from the mesoclimate of the lake and its proximate environs, where the submediterranean precipitation distribution has no role (directly even the precipitation has neither since the soil is steadily water saturated; the soil level coincides with the water table!), the matutinal fog is frequent and the nocturnal-matutinal dew formation on the vegetation is almost perpetual. This mesoclimate is more kindred with the high mountain continental and the more nordic cool-temperate climates – at least from the point of view of important parameters for the livings, – as the vegetation unequivocally indicates it.

The soil climate of this mesoclimaticfarea is segregated in several, from each other just differing but certainly differing microclimatic spaces (as for example the willows, the reeds, the *Sphagnum* marsh have alike a soil of a temperature course being very egalized, the temperature oscillations of their corresponding layers is almost identical but their absolute values differ significantly from each other by several tenth of centigrade; coldest is the soil of the *Sphagnum*, warmest is the soil of the willows).

At the time of our measuring series and preceding that we carried out several times longer-shorter measuring series, partly on the sudds in order to select the measuring spots appropriately, on the other hand on open waters; and on these same spots we carried out many air temperature measurings (C z e g l é d y et al. 1978). However – as a consequence of the informative character of our measurings – they were not carried out by uniform directing principles, thus the results of these measuring series are here not published. This work is properly speaking only a preliminary study on the microclimatic relations of the sudd world and on the basis of this we plan a comprehensive microclimatic measuring series on the sudds of Lake Velencei, on the smaller-larger waters between them andon the great open waters. (We hawe especially difficulties in the air layers above the soil of the sudds. At the heights adapted the routine measurings we did not get significant differences, but there were great differences between the temperature of the 10 cm air layer and of that of the soil surface. After several attempts we established that we should measure by centimeters between the soil surface and 5 cm but at least in 1, 2 and 5 cm heights the temperature of the air. These investigations elucidated that in the air space of the plant associations of the sudd the air temperature is generally by several degrees lower than above the open water (C z e g l é d y et al. 1978). With this method, on the contrary, we do not possess 24 hours measuring series, thus we find it more correct not to publish data here. Nevertheless, we consider our measuring series carried out on the sudd soils as a round entity while they elucidate the differences existing between the climates of the sudd and marsh meadows, furthermore of the sudd and *Sphagnum* marsh, moreover of the sudd and aquatic environs, it proves that the closed sud world of the western basin of Lake Velencei of several square kilometers extension constitutes an independent mesoclimatic space opposite to the lacustric mesoclimate and explains the existence of an Atlantic-montan-boreal marsh and sylvan flora in a shallow, easily basking lowland (saline!) lake.

Summary

The most important aim of our investigations was to get acquainted with the temperature course of the sudd soils of Lake Velencei, to establish the characteristic features of the microclimate, to find an explanation to that seemingly extraordinary floristical phenomenon that in a shallow lowland saline lake a precious marsh vegetation grows (which is likely a postglacial relict).

As a result of our work we may establish that:

– the sudd soils are very cool, their temperature course is more egalized than that of the marsh meadows as well as of the *Sphagnum* marshes,
– the temperature of the water bodies beneath the sudds, furthermore of the waters of the sudd tarns is by many degrees lower than above the open waters,
– the air temperature on the sudds is generally by many degrees lower than above the open water,
– the sudd area constitutes an independent mesoclimatic space, the features of which differ significantly from the lacustric mesoclimatic space.

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